Innovation and Social Change

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When educators attempt to implement an innovation, they typically face a complex challenge of meshing new ideas with well-established beliefs and practices. As a result, they often realize the innovation in a way that reflects situation-specific compromises between the old and the new ways of doing things (Bruce & Peyton, 1990; Bruce & Rubin, 1993; Rubin & Bruce, 1990). A major goal of this book is to explore this process of realizing innovations and to consider the implications for models of educational change, for the evaluation of innovations (Cronbach, 1982), for the role of teachers in implementing innovations (Hord, Rutherford, Huling-Austin, & Hall, 1987), and even for the basic notion of what an innovation is.

The linking of new technologies to a vision of transformed pedagogy is a distinguishing feature in many proposed innovations in education. It is rare that the developer of an innovation would adopt the goal of simply facilitating current practices with a new technology. The reification of the developers' pedagogical theories is viewed as vital to achieving their pedagogical goals, and the argument is made that the expense of adopting new methods and tools is justified by the major improvements that will occur. Conversely, proposals to transform teaching practices often incorporate new technologies, which might include new media, computers, curricula, kits of manipulatives, or step-by-step procedures for teaching or learning.

Thus, new technologies are commonly linked to visions of educational change. Sometimes the new technology is viewed as sufficient unto itself to effect the desired changes. In that case, we succumb to technocentrism (Papert, 1987), the tendency to conceive technology independent of its contexts of use. With this mindset, we assume that if only teachers and students had access to the power of the new technology, all aspects of the wonderful vision would be realized.

Studies of the process of educational change (e.g., Fullan, 1982) show that access to new information, procedures, or tools alone rarely leads to change. One reason is that the same technology has different meanings in different settings. The already functioning social system and traditional practices in which the technology is placed shape the ways the technology is understood and used. In fact, those who do adopt innovations are typically faced with a challenging task of resolving conflicts between old practices that derive from powerful situational constraints and imperatives of the new technology. As these conflicts are resolved by different people in different settings, the original technology takes on multiple forms; the it becomes them.

In this book we examine the process by which ENFI was realized in many classrooms. But the general form of the process recurs for the introduction of any innovation, whatever the domain. The parameters, constraints, and issues related to change are in large part the same across settings; accordingly, the examples in this chapter come from a variety of fields. Many of the examples pertain to innovations that incorporate new technologies, but the essential

points apply to all innovations, even those built around older technologies such as books, paper and pencil, or the blackboard.

We view an innovation as the manifestation of a set of beliefs and values about change. Thus when we refer to the innovation, we include not only pieces of software or hardware, but also all of those documents and practices that define and support its intended uses. At a minimum these include user's guides, documented examples of previous use, training for users, and texts describing the innovation. But in the final analysis, we see an innovation as a process - the meeting ground of various interests and practices. What we need to investigate is the meaning of this broader sense of the innovation for the social systems in which the innovation is used.

This view raises some broad questions: Under what circumstances will a social system change, resist change, or change in unexpected ways? What is the role of innovations in producing change? What institutional factors promote or inhibit change? How can we best analyze the process of change when it does occur? What are the implications of these issues for the evaluation of innovations?

Discourses on social change

Discourse is a useful construct for describing differing approaches to the study of *Innovation and Social Change*. For the purposes here, we conceive a discourse as a socially, culturally, and historically defined set of social relations, manifested in large part, though not exclusively, through language use (Gee, I 990).

We begin this chapter by looking at two conflicting discourses on *Innovation and Social Change*. One is innovation focused; it talks of changes in social systems brought about by an innovation. Within this discourse, these changes are seen as significant and positive. The second discourse is social system focused; it emphasizes underlying social, cultural, economic, or political processes that undermine innovations, resulting in negative outcomes or, more often, precluding any change at all.

For example, Lepper and Gurtner (1989) describe both the "dream" and the "nightmare" visions of the use of computers in education. The dream is characterized by accounts of how using computers will lead to restructuring of classrooms, student control of learning, greater engagement, more challenging activities, development of thinking skills, and deeper understanding of subject matter. The nightmare sees few positive changes as it looks at existing social practices, power relationships, surrounding contexts, conflicting goals, and cultural values. It usually concludes that technological factors are of little consequence. Similarly, Hawisher and Selfe (1990) contrast the "rhetoric" and the "realities" of technology.

The differences between the two discourses are thus great and difficult to reconcile. We argue that neither discourse alone accounts for important aspects of technological and social change; rather, an integrated model is needed. From this integrated perspective we discuss six major ways that change occurs when innovations are introduced into social systems.

Innovation-focused discourse

The two discourses focus on different issues; they also criticize each other for not sharing that focus. From an innovation focus, therefore, we read that social scientists give little heed to the workings of technological innovations. Writing about change in an article introducing a special issue of Scientific American on the mechanization of work, Ginzberg (1982) adopts

an innovation focus. He sees economics as impoverished by its lack of acknowledgment of the importance of technology: "Most economists - free market, Marxist, or otherwise - have failed to give technology its due" (p. 69). Classical theories assume static technologies as they explicate "with ever greater subtlety how demand, supply, and price interact in competitive markets to establish or reestablish equilibrium" (p. 69).

Similarly, within anthropology Bernard and Pelto (1987) see other anthropologists as neglectful of the importance of technological innovation:

> The study of technological innovation and its effects on social and cultural systems remains one of the most neglected areas in anthropological research. Very few anthropological studies have concentrated on the analysis of particular technological innovations or changes, even though field workers are constantly reminded, in the course of research, of the penetrations of roads, dams, air travel facilities, new types of vehicles, medical systems, new cultivation techniques, and other technical modifications into previously "untouched" areas. (p. 1)

Innovation-focused discourse tends in practice to highlight improvement in conditions - for work, communication, transportation, learning, health, or whatever area the innovation addresses. These improvements are generally seen as entailing significant change and are often unabashedly described as "revolutions." Not surprisingly, innovation-focused discourse tends to include mostly references to the future. When it does refer to the past, it points to long-term trends, rather than to underlying forces that resist change. Because the changes are positively valued, the tone is generally optimistic. For example, as Ginzberg (1982) says,

> The easing of human labor by technology, a process that began in prehistory, is entering a new stage. The acceleration in the pace of technological innovation inaugurated by the Industrial Revolution has until recently resulted mainly in the displacement of human muscle power from the tasks of production. The current revolution in computer technology is causing an equally momentous social change: the expansion of information gathering and information processing as computers extend the reach of the human brain. (p. 67)

Innovation-focused discourse assumes not only that change is possible and that it does occur, but that the goal of discussion is to articulate the path to that change. Thus its stance is essentially that of the engineer. Goals are identified and contrasted with existing practices. Technology is described in terms of what it can do in achieving these goals, and only incidentally in terms of what it is actually used for. There are frequent references to efficiency, productivity, and new ways of thinking. More often than not, positive examples are highlighted. Problems are presented as remaining obstacles to overcome, not as reasons for ultimate failure. The tone is often visionary, rejecting detailed analyses of current practice as being too conservative.[1]

> An extreme innovation focus assumes that the innovation directly changes social practices. The social system is seen as an arena in which the innovation does its work. Variations in use are attributed to improper implementation. This assumption underlies the dominant theories of evaluation today and shapes

> many analyses of social change, as well as the design of innovations. Papert (I 987) relates this extreme innovation focus on the technological object to a child's early focus on the self:

Egocentrism for Piaget does not, of course, mean "selfishness" - it means that the child has difficulty understanding anything independently of the self. Technocentrism refers to the tendency to give a similar centrality to a technical object - for example computers or Logo. This tendency shows up in questions like "What is THE effect of THE computer on cognitive development?" or "Does Logo work?" (p. 23)

Social system-focused discourse

The discourse focused on social relations and organizations has a complementary complaint. It sees discussions of technologies as too often isolated [1] from an understanding of the settings in which the technologies are used. For instance, in a discussion of the role of technologies in education, Michael Apple argues that too much attention is paid to technical issues and too little to the political context in which technologies are employed. The current political context highlights issues such as accountability, management, and control. From the perspective of social system-focused discourse, technical concerns are seen as superficial, political concerns as central: "At the very core of the debate, are the ideological and ethical issues concerning what schools should be about and whose interests they should serve" (Apple, 1986, p.153). Focusing on the technical aspects of the innovation is seen as failing to address crucial ideological and ethical issues.

In contrast to the generally optimistic tone of innovation-focused discourse, system-focused discourse tends in practice to be pessimistic; it typically finds little real improvement, and what change there is is incremental and slow. Rather than revolution, it finds reemergence or reinforcement of established patterns that are often negatively valued. For example, writing about the minimal positive effect that mechanization has had on women's work, Scott (1982) said,

> In certain essential respects, however, the work that women do has changed little since before the Industrial Revolution.... A decade of historical investigation has led to a major revision of the notion that technology is inherently revolutionary, at least as the notion applies to women. The available evidence suggests that on the contrary mechanization has served to reinforce the traditional position of women both in the labor market and in the home. (p. 167)

System-focused discourse thus has a stance complementary to the, engineering stance of innovation-focused discourse. It takes on the role of the critic. It places little faith in visionary goals, or in the methods for reaching those goals. Instead of looking to the future by articulating a plan for change, system-focused discourse looks at actual use and asks whether anything has changed. It is less concerned with what the technologies could in principle do and more with what they are actually used for in ordinary contexts. Problems are seen not as obstacles to overcome, but as indicators of underlying systemic processes that the innovators have not even addressed. It is skeptical of claims about the impact of innovations and assumes that, absent strong evidence to the contrary, everything is likely to continue to be "the same."

Although social system-focused discourse may not attend to the specifics of a given

technology, it is noteworthy that it tends to use the plural form, *technologies,* whereas innovation-focused discourse often refers to *technology* in general. The multiple forms and meanings of technologies are thereby emphasized and subjected to criticism, rather than accepted as a monolithic force (Bijker, Hughes, & Pinch, 1987; Staudenmaier, 1985).

Integrating analyses of change

Conflicting discourses arise naturally when the issues are complex and diverse, militating against a single, coherent perspective. More importantly, different agendas invoke different ways of talking about social change. The designer of an innovation naturally focuses on technical details, just as the social critic focuses on social processes. But the maintenance of separate and parallel perspectives hampers our ability to understand social change and to design better innovations.

> Suchman (1988) describes the two discourses as "separate spheres":
>
> By and large, we are taught to view the political and the technological as separate spheres, the former having to do with values, ideology, power, and the like, the latter having to do with physical artifacts exempt from such vagaries of social life. (p. 174)
>
> The maintenance of these separate spheres makes it difficult to see how changes to a social system occur through other than simple, one-directional causation. This impedes both the development of successful innovations and the understanding of social change.

Latour (1986) makes a similar point in his discussion of an example of mapmaking. He tells how the French explorer La Perouse journeyed to the island of Sakhalin. While there he drew a map of the island, based on information provided by people who lived there, people who had themselves never made or seen a map on paper. He then returned with the map to the court in Versailles. In order to understand such things as why La Perouse undertook such a long journey (and to Sakhalin in particular), why it was so important for him to produce such a map, why the map needed to be on paper, how he was able to find his way there, why it was not important to the Sakhalin residents to have such a map, and so on, one must understand intricate technological and sociopolitical details; but more importantly, one must understand the way social relations are mediated by technical artifacts. As Latour says,

Commercial interests, capitalist spirit, imperialism, thirst for knowledge, are empty terms as long as one does not take into account Mercator's projection, marine clocks and their markers, copper engraving of maps, rutters, the keeping of "log books," and the many printed editions of Cook's voyages that La Perouse carries with him.... But, on the other hand, no innovation in the way longitude and latitude are calculated, clocks are built, log books are compiled, copper plates are printed, would make any difference whatsoever if they did not help to muster, align, and win over new and unexpected allies, far away, in Versailles. The practices I am interested in [inscribing information in permanent, but mobile forms] would be pointless if they did not bear on certain controversies and force dissenters into believing new facts and behaving in new ways. (p. 6)

Thus neither an innovation focus nor a system focus is sufficient to understand this or many other historical events. Latour's notion of "inscription," in which technology is used to produce "immutable mobiles," is one construct useful for integrated analyses. Another is the idea that the design of an artifact is mediated by social relations. Akrich (1992) shows how

"technical objects and people are brought into being in a process of reciprocal definition" (p. 222). Design of technology is a process that represents the intersection of the physical apparatus aspect of technology with its social relations aspect.

For example, she describes the design of a photoelectric lighting kit for use in less-developed countries. One design goal was that the kit should work in spite of any environmental (or user) interference. It had a watertight battery for anticipated use in exposed environments. It was designed without a switch and with nonstandard plugs to prevent tampering by unsophisticated local electricians. This physical design expressed the French designers' assumptions about the knowledge and capabilities of the users in another country. The effort to produce an interference-proof kit reflected other aspects of the social relations between designers and users as well. It is clear, for instance, that the prevention of interference was not simply a convenience for the user, but an effort at control from afar.

Functional specifications cannot be separated from a complex of social relations. A consequence in this case was that the lighting kits could not be used successfully for long. True, the lights could not be modified by local technicians, but they could not be repaired either. The special watertight battery was not available in local markets. Clearly, understanding the usefulness of the kits requires an understanding of both technical and social systems.

The design of any technology must be understood not simply as the construction of a physical artifact to meet a functional specification, but as a process in which relations among people are realized. By observing the use of the lighting kits, we begin to see how these relations are embodied in the technology. Akrich (1987) points out that we cannot even see the structure of the kit without seeing it in use:

> Before leaving Paris for Africa, the potential significance of nonstandard plugs, direct current, or waterproof batteries had not occurred to me. It was only in the confrontation between the real user and the projected user that the importance of such items as the plugs for the difference between the two came to light. The materialization and implementation of this technical object, like others, was a long process in which both technical and social elements were simultaneously brought into being-a process that moved far beyond the frontiers of the laboratory or the workshop. (p. 210)

An earlier work with an affinity for Akrich's notion of the simultaneous fabrication of technical and social elements is that of Victor Papanek (1973). A successful and prolific designer, who like Akrich is concerned with design for the third world, Papanek argues for design teams that include representatives of the people who will use the design. This is one element in his idea of "integrated design." He presents many examples of designs that could lead to safe, inexpensive, and useful innovations, contrasting those with other designs that are dangerous, expensive, and of little inherent value. His central conclusion is that an integration of technical and social issues is necessary: "The main trouble with design schools seems to be that they teach too much design and not enough about the social, economic, and political environment in which design takes place" (Papanek, 1973, p. 193).

Rethinking the realization process

Examples such as those given by Akrich make it difficult to maintain a view of innovations as fixed objects that get applied to produce changes in social systems. Instead, they lead us to

see innovations as processes, ongoing man-ifestations of social relations. This calls for a historical perspective in which we follow social changes over time, including those changes related to the development of the innovations. In contrast to an innovation focus or a system focus, we need to conceive of the adoption of an innovation as a process in which innovations are incorporated into a dynamic social system that may lead to changes in the innovation, acceleration of change in the social system, or no effect at all.

An important distinction to make is that between what the developers of an innovation intend and what happens when the innovation is realized in a particular social setting. The developers may intend that the innovation modify the social system so that certain desirable characteristics are achieved. They see the innovation set into an idealized context and used in an idealized way. Their vision of the changed social system is thus an idealization. What happens in practice is that the social system may or may not change at all, and if it does change, it may not do so in accord with the developers' goals. Each resulting social system is a realization. The distinction between ideal and real suggests a process, the realization process, whereby the innovation leads to practices potentially different from those intended by the developers.

It is possible to view a realization as a distortion of the innovation, just as Plato saw every actual circle with "particular qualities" as an imperfect manifestation of the real circle (Hamilton & Cairns, 1961, 7.343a-c). This view is represented in Figure 1-1. The solid circle on the left represents the effect of the innovation in an ideal world, the lens represents the realization process, which distorts the ideal form, and the dotted shape on the right represents a particular realization.

The widespread prevalence of "distortions" of innovations is a clue that the conventional model of implementation is inadequate. It fails to account for the fact that existing goals and practices of institutions and individuals determine what happens with an innovation more than features of the innovation itself (Bruce & Rubin, 1993; Cohen, 1988; Cronbach, 1982; Cuban, 1986; Hawkins, 1987a; Kling, 1980; Kling & Scacchi, 1982; Rubin & Bruce, 1990). In reality, the innovation is but one small addition to a complex social system. Instead of seeing it as the primary instrument of change, it is better to see it as a tool that is incorporated into ongoing processes of change.

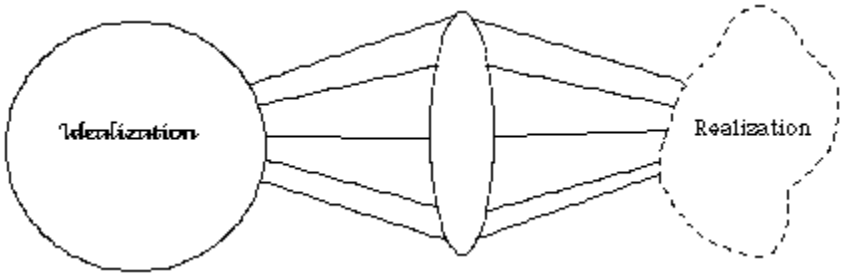

Figure 1-1. A Platonic view of the realization process

We are thus led to a different model for implementation of innovations. In this model, the active agents are not innovations, but the participants in the setting in which the innovation is placed. Participants interpret the innovation and then re-create it as they adapt it to fit with institutional and physical constraints, and with their own goals and practices. The Platonic view is thus inadequate; social practices related to the use of an innovation are not imperfect attempts to mimic some ideal form, but are rather the thing itself. Whereas we may contrast the use of an innovation with its idealization, we do not assume that users are imperfectly

following preset rules. The situation instead is more akin to Wittgenstein's (1953) language games:

> In philosophy we often compare the use of words with games and calculi which have fixed rules, but cannot say that someone who is using language must be playing such a game. - But if you say that our languages only approximate to such calculi you are standing on the brink of a misunderstanding. For then it may look as if what we were talking about were an *ideal* language. (¶ 81)

Wittgenstein goes on to show how language *use*, not some rigid set of rules, determines meaning. Nevertheless, many continue to search for the vacuum bottle ideal for language: "We think it [the ideal] must be in reality; for we think we already see it there" (¶ 101).

In a similar way, we cannot specify the pure, or ideal, case for the use of an innovation, only its idealization in the minds of the developers. Users inevitably interpret an innovation in distinctive ways, apply it idiosyncratically in their own contexts, and even re-create it to satisfy their own needs. We say that the innovation that is not prepared for this reshaping is poorly designed, not that it is maligned by the user.

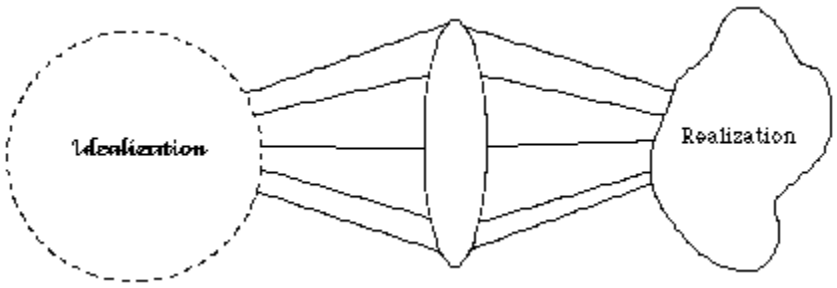

Figure 1-2. A Wittgensteinian view of the realization process

Again, Wittgenstein's discussion of games is apropos:

> We can easily imagine people amusing themselves in a field by playing with a ball so as to start various existing games, but playing many without finishing them and in between throwing the ball aimlessly into the air, chasing one another with the ball and bombarding one another for a joke and so on. And now someone says: The whole time they were playing a ball-game and following definite rules at every throw.
>
> And is there not also the case where we play and — make up the rules as we go along? And there is even one where we alter them — as we go along. (¶ 83)

The innovation-in-use, like the actions of people playing with a ball, is the phenomenon we want to understand. A better view of the realization process is that shown in Figure 1-2, in which the solid shape on the right represents a specific and quite tangible set of social practices that emerge after the introduction of an innovation. Its characteristics reflect a

history of interacting social processes, of which the innovation is only a latecomer, and one whose effects are shaped by layers and layers of previous events. The dotted circle on the left is the idealized form of the innovation, an imagined system, whose correspondence to the given realization depends as much upon the developers' understanding of the context of use as upon the inherent power of the innovation to effect change. In other words, its similarity to the realization depends upon the developers' assessment of the underlying social processes in the context of use.

The diversity of the realization process is revealed as we examine what happens when an innovation is introduced into various settings. As social relations and structures vary across settings, one idealization spawns an indefinite number of realizations. Continuing our optics metaphor, we might say that instead of the realization process being a lens, it is a prism that produces a wide spectrum of different realizations (Figure 1-3). As an innovation comes into being in real settings, it acquires new and unexpected shapes. It is not only used differently, it is re-created to conform with the goals and norms of the people who use it.

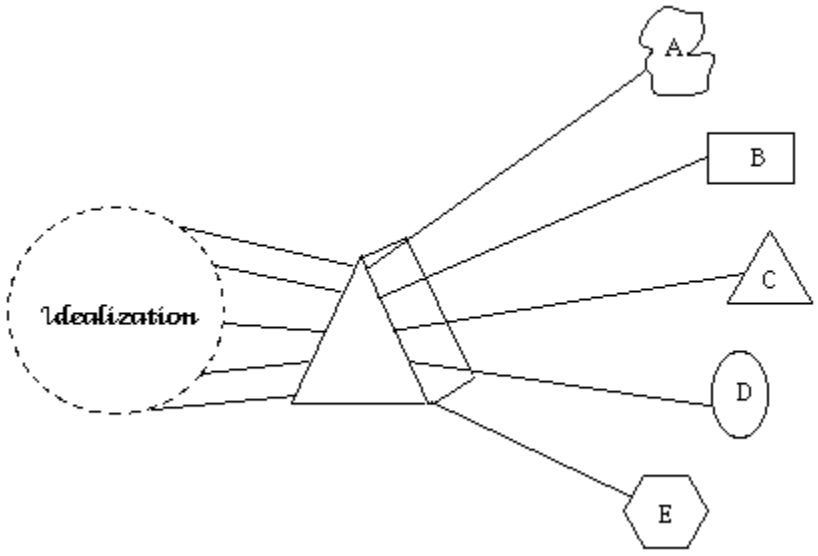

Figure 1-3. Alternate realizations of an innovation

How innovations develop

Because innovations come into being through use it is difficult to predict the eventual patterns of use for an innovation. In some cases developers or social critics overestimate the likely acceptance of and need for the innovation. Thus the video or picture telephone now seems unlikely to be a commonplace device by the year 2001, belying Stanley Kubrick's portrayal of it in 2001: A Space Odyssey. Yet long before that film was produced, AT&T (American Telephone & Telegraph) had introduced its Picturephone system at the 1964 New York World's Fair. Many people then considered the picture telephone to be an obvious and inevitable next step in the telephone's evolution. In the ensuing 27 years, however, the cost, quality, and usefulness of the device never crossed the necessary threshold into widespread consumer use. AT&T offered a consumer video telephone for the first time in 1992.

There are endless examples of other potentially useful technologies that have not been adopted widely by the consumer - videodiscs (for home use), central vacuum cleaners, and

so on - each touted as imminent by some people at one time. The adoption of these technologies must be understood in terms of the social contexts of potential use, not just in terms of the speed, efficiency, or polish of the new innovation per se (Bijker, Hughes, & Pinch, 1987; MacKenzie & Wajcman, 1985).

In other cases people underestimate the growth of an innovation. The xerographic process is a notable example. Thought of first as a novelty or a specialized tool, copy machines have transformed offices everywhere and are now being marketed as standard home appliances. Other technologies that we view as ordinary, even necessary, today were likewise exotic in their beginnings. Telephones, televisions, faxes, computers, and automobiles are examples of technologies that have radically reshaped our lives in ways few predicted. These underestimated technologies satisfied hidden needs or created new ones. Viewing their impact in quantitative terms alone (a car as moving four times as fast as a horse, for example) would only obscure the complex ways in which the technology transformed the social world and was in turn transformed by it.

One reason it is difficult to assess the impact of an innovation is that change can occur through diverse processes. The innovation can be re-created along many different paths. At the simplest level, the social system may assimilate the innovation and exhibit incremental change. More generally, one change in the system may trigger other changes, so that there is a cascade of connected changes. Typically these changes occur independent of or even counter to anyone's overt plan. Sometimes the new social practices called for by the innovation are dissonant with existing social values. Ultimately this can lead to a change in values. In other cases dissonance can lead to nonstandard uses, or to resistance to the innovation expressed through token use or nonuse.

Finally, change may occur because of a modification of the innovation by either developers or users. People make up the rules or alter them as they go along. These types of changes are often slighted in discussions of technology and social change, perhaps because the analyst sees the technology as something fixed and imposed from the outside. In fact, innovations are by nature experimental and typically die if they do not allow re-creation. Higher-order changes may come through the re-creation process as well. Often, in fact, we see a cascade of changes to both the innovation and the context of use, each triggering changes in the other.

Thus in practice it may be difficult to say exactly which type of change is occurring, and any real example is likely to involve a mixture of these types. Moreover, the judgment that a particular type of change has occurred is an interpretation from within a discourse. For example, "consonant change" and "cascades of changes," as defined in the following text, are most often cited in innovation-focused discourse, and "change due to dissonance" is more often noted in system-focused discourse. With these caveats in place, it is still useful to make some abstractions of the realization process as we look briefly at several important types of change. Figure 1-4 shows some of the major paths of change in an idealized form. It is meant to be only a sketch of some of the possible forms of change that take place as an innovation is realized.

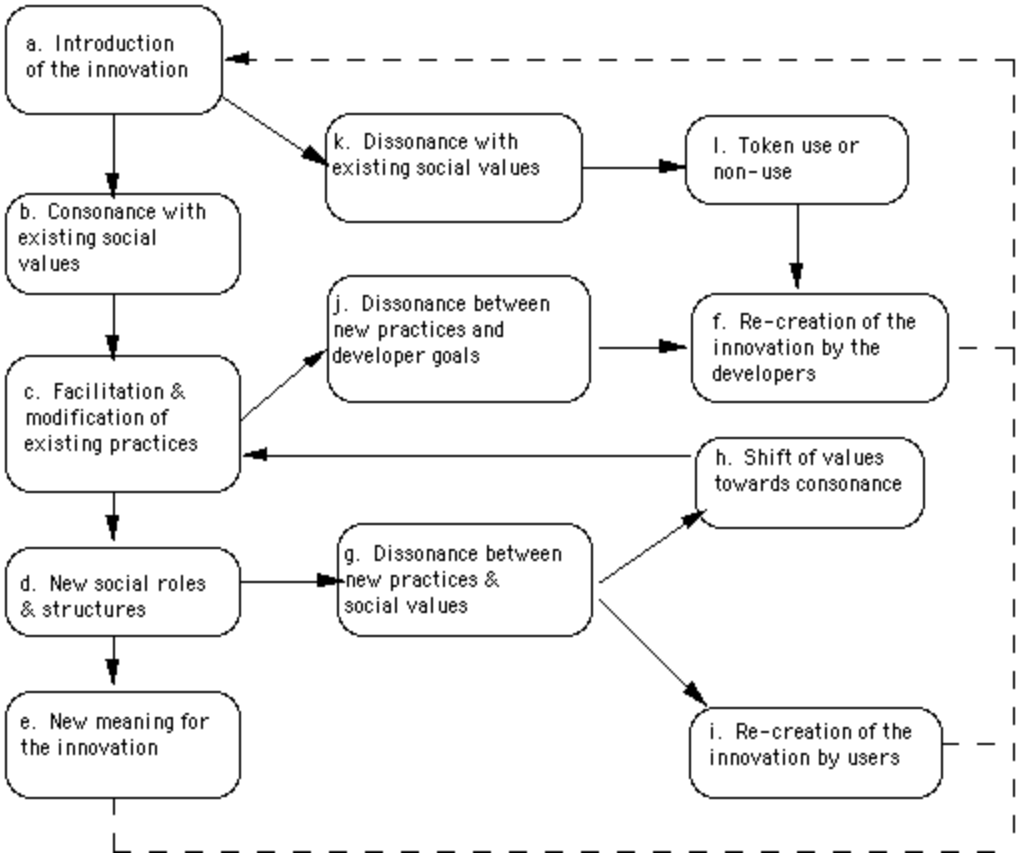

Figure 1-4. Idealized model of paths of social change

Consonant change. The simplest sort of social change following the introduction of an innovation is that in which the innovation is consonant with the values of the social system, in which case it facilitates, extends, or perpetuates existing social practices. These practices change exactly enough to assimilate the innovation. Typically the innovation promises greater productivity for existing functions. Pure consonant change does not exist, but aspects of it are common when an innovation is introduced, especially in early stages of use. This is the type of change usually assumed in innovation-focused discourse.

The process for consonant change is relatively simple. An innovation is introduced. If it is consonant with existing social values, it is adopted easily. Existing social practices are facilitated and may change somewhat as the innovation is used. Schematically, then, the pattern for simple consonant change is the @a-b-c) path in Figure 1-4. In some cases, the process could be viewed as stopping after some modification of existing practices.

For example, many discussions of office automation begin by describing how documents can be produced, stored, or exchanged more quickly and cheaply — basically a substitution of new processes for old. The change in processes may also lead to higher quality products. Moreover, there can be changes in the time and place dependence of work. Further analysis includes some social change issues such as the extension of managerial control or changes in office organization (Evans & Bernard, 1987). But often, these discussions assume no change in the fundamental purposes for documents or the social roles of office workers; the emphasis is on technical capabilities, economic factors, and user acceptance.

Examples of discourse assuming consonant change can be found in a book addressed to managers making decisions about electronic mail for the office (Caswell, 1988). The book details the history of the technology, explicates technical details, and lays out options for the

managers. It lauds electronic mail as a technology that "adds regularity" to existing processes:

> Electronic mail, however, has a long-term impact that is far broader. Because electronic mail adds regularity to our telecommunications network, it makes a critical contribution to our evolving system of global communications, which is a necessary component for the evolution of mankind. In this context, developing electronic mail systems is a noble pursuit. (p. xiii)

The text continues with the claim that the impact on people of this new technology is quite straightforward, despite the technical complexities:

> Although the networks and the technologies that create them are quite complex, the implications are very simple. Advanced information networks will magnify the ability of people to store, gather, prepare, and communicate important information. (p. 1)

Thus the central issue for managers is simply to determine how to ensure that the new technology gets used:

The challenge, which extends to both top executives and mid-level managers, is to cut through the complexity of the myriad technologies on the market and mold them into a unified, integrated network that serves the people who use them. (p. 1)

The assumption here is that there is no significant difference between the sense of "communication" embodied in existing office practices and that embodied in electronic mail, and thus that the types of change described therein would be consonant. But there are good reasons to doubt this assumption. New technologies such as electronic mail provide new arenas for sorting out social relations; the uses of the technology are never straightforward extensions of existing practices. Nevertheless, the assumption of consonant change and the corresponding focus on the innovation is representative of the writing typically found as an innovation is being introduced or promoted.

Dissonant change. Change attributable to an innovation is often not smooth; in fact, it may be disruptive in ways that have little to do with the innovation's purported function. People may resist the innovation or use it in ways never intended, or social systems may be profoundly disturbed by its presence. A model for one aspect of dissonant change has been proposed by Bernard and Pelto (1987). In their model the introduction of new technology calls for new practices, but not immediately for new ways of thinking. These new practices may conflict with established cultural ideas. The dissonance thereby produced can lead to a shift in values:

A key mechanism for bringing about behavioral (social) change is the drive to reduce cognitive dissonance — the tendency to change values (e.g., in response to new technology) when new behaviors (in response to new technologies) are longer consonant with previously held values. This mechanism is presumed to operate, for example, when a farmer changes his economic activities, especially if those economic activities no longer produce sufficient income to maintain the standard of living that his family has come to value. (Bernard & Pelto, 1987, p. 362)

A classic example of this is the story of the introduction of the steel axe to the Yir Yoront

people living on the west coast of Cape York in Australia. Sharp (1952) tells how the Yir Yoront accepted this modern tool, but only for the stone axe, not as the multifaceted tool it was in other settings. Thus there was initially a consonant change without notable positive effects or any cascade of positive changes (discussed in a later section):

> Among the Yir Yoront the new axe never acquired all the uses it had on mission or cattle stations (carpentry work, pounding tent pegs, use as a hammer, and so on); and, indeed, it was used for little more than the stone axe had been, so that it had no practical effect in improving the native standard living. It did some jobs better, and could be used longer without breakage; and these factors were sufficient to make it of value to the native. (p. 82)

But the adoption of the steel axe did lead to many other changes. Stone axes were more than tools for cutting wood; they served symbolic functions axes as well. Stone axes signified power in the hands of the older men, who were allowed to possess them. Steel axes were, in contrast, plentiful; they were given to women and to younger men by missionaries and other outsiders:

A result was that older men no longer had a complete monopoly of all the axes in the bush community. Indeed, an old man might have only a stone axe, while his wives and sons had steel axes which they considered their own and which he might even desire to borrow. All this led to a revolutionary confusion of sex, age, and kinship roles, with a major gain in independence and loss of subordination on the part of those able now to acquire steel axes when they had been unable to possess stone axes before. (p. 84)

These were changes to the basic social structure of the community. But as dramatic as they were, other effects of the presence of the steel axe may have been more profound. The most disturbing changes emerged "in the realm of traditional ideas, sentiments, and values" (p. 85). There was a need to account for this new and now important element within the community, but the steel axe was neither "always there" nor created by a known clan. It was first associated with the Corpse clan, as were all other things pertaining to the white man. This posed a conceptual dilemma because the stone axe is a totem of the Sunlit Cloud Iguana clan and the steel axe seems to belong there as well:

> Moreover, the steel axe, like most European goods, has no distinctive origin myth, nor are mythical ancestors associated with it. Can anyone, sitting of an afternoon in the shade of a ti tree, create a myth to resolve this confusion? No one has, and the horrid suspicion arises that perhaps the origin myths are wrong, which took into account so little of this vast new universe of the white man. The steel axe, shifting hopelessly between one clan and the other, is not only replacing the stone axe physically, but is hacking at the supports of the entire cultural system. (p. 88)

Sharp concludes that an eventual consequence of the introduction of the steel axe was the collapse of a system of ideas and, subsequently, "cultural disintegration" and "demoralization of the individual" (p. 89). Thus, dissonance between values embodied in the new practices associated with the innovation and those of the social system led to dramatic cognitive and social turmoil little evident in the technical artifacts. This in turn led to a shift of values for those affected by the innovation.

In the terms of Figure 1-4, the first part of the process was the same as that for consonant change. People adopted the innovation and changed their practices accordingly because it

was consonant with some existing social values. The changed practices, though, were dissonant with other social values. Values then shifted to reduce the dissonance. Schematically, it looks like the path (a-b-c-d-g-h) in Figure 1-4. The key is step g, the point at which dissonance emerges between new practices and existing social values.[2]

Thus when changes in a community occur following the introduction of an innovation, the types of change reflect the match between the values manifested in the innovation and those in the social context of use. When the match is dissonant there can be rejection of the innovation (discussed in the section to follow), radical changes in its modes of use (i), re-creation of the innovation (f), or shifts in values for both users and developers of the innovation (h) (as in the stone axe example). Any study of the adoption of an innovation must therefore take into account existing values and beliefs, the ways they affect its adoption, and the ways they are themselves changed in the process.

Resistance to change. Often, no change occurs at all. Innovations too often succeed in pilot tests and then fail to have any lasting impact on the system as a whole. The nonuse of many patented inventions and the failure of technologically innovative products and companies attest to this fact. A model for this response of the social system to an innovation looks like the path {a-k-l} in Figure 1-4.

In the realm of education, one reason for resistance to change is that there are conflicting functions for schools, as democratizing institutions and as institutions for sorting people into jobs and status within society (Bowles & Gintis, 1976). Another is that instruction is typically organized in a way that modifies an innovation to fit or rejects the innovation if it cannot be modified. Cohen (1988) makes this point based on a historical analysis of a variety of new curricula:

> So, while the new curricula were used, they were used within the extant organization of instruction. In a minority of cases this meant they were used intelligently and sympathetically, but even in these cases the new content did not bring radical change in the ways that classes were conducted, that teachers taught, or that students learned. But in most cases, the new curricula were assimilated to an inherited and rather rigid organization of subject matter, teaching, and learning. In either case, it seems fair to say that the new materials seem [not] to have changed the organization of instruction in any dramatic way. More often than not, the extant organization changed the materials. (p. 237)

A similar point is made by Cuban (1986). New technologies are incorpo-rated only if they facilitate existing practices:

> Thus, those technologies incorporated into routine teacher practice responded to daily classroom needs without undercutting the teacher's control of the class.... Teachers have altered their practice when a technological innovation helped them do a better job of what they already decided had to be done and matched their view of daily classroom realities. (pp. 65-66)

In some cases users may do the opposite of what is intended. One reason this occurs is that there are contradictions within the innovation's design that *become* apparent only with use. More precisely, aspects of the design become contradictions when realized in certain contexts. For example, the use of word processing in classrooms for the teaching of writing has often been linked with a deemphasis on formal aspects of language in favor of an

emphasis on meaning (Bruce, 1991). Printed output, which is neater and easier to read than handwritten copy, is seen as a way to encourage students to think more about their audience and meaningful purposes. But, paradoxically, because printed output reveals mistakes and looks more finished, it has led in some classrooms to an increased focus on spelling and punctuation.

Similarly, visions for the computer in the classroom may include the idea of a writer turning to the computer to make changes as the need for them naturally arises during the thinking/writing process (Bruce & Rubin, 1992). This model assumes that the writer can spend time at the computer pondering the text and making complicated edits. In many school situations, however, there is limited computer access. This resource limitation becomes relevant when teachers attempt to ensure equity of use. Most teachers ensure equity of use by giving each student a fixed period of time per week, say 30 minutes, to use the computer. The result is that students cannot go to the computer to make changes to their texts as the need arises. Nor can they afford to use their limited time allotment to sit and think about their text. Instead, they have to use the time for pressing keys. This means that copyediting is often the only reasonable way to use the time effectively. Thus in a context in which there is limited computer access and the allocation of fixed, equal portions of time to each student, the dimensions of equity and meaning-centered revision come into conflict.

An important type of resistance to change is that which occurs when an innovation attempts to alter existing forms of distribution in society. Addressing inequities in classrooms has been a major goal of many innovations that are based on new technologies. As Foucault (1972) says, however, "We well know that in [education's] distribution, in what it permits, and in what it prevents, it follows the well-trodden battle-lines of social-conflict" (p. 227). These innovations do little to change underlying inequities.

The most pernicious effects may occur when innovations are used well, for differential access may compound the inequalities in education that already exist between rich and poor, black and white, male and female. Such a compounding is evident with computer use (Hawkins, 1987b; Russell, Mokros, & Foster, 1984). Wealthier schools have greater access to new technologies. Moreover, students in wealthier schools more often use computers for open-ended learning activities, such as writing, Logo programming, and science simulations, whereas students in inner-city schools use them for drill and practice on basic skills (Boruta et al., 1983; Shavelson et al, 1984). Even within a single classroom there is evidence that the distribution of access and information "follows the well-trodden battle-lines of social-conflict." Students already marginalized in special programs become more so when they miss the introduction to the computer because of being pulled out of class (Michaels, Cazden, & Bruce, 1985).

Cascades of changes. Changes beget other changes. In the appropriate con-text, an innovation may have unanticipated secondary and tertiary effects. As Burke (1978) suggests, there can be a "trigger effect." When conditions are right, a new innovation can set in motion a "continuing sequence of connected events" (p. 12). For example, in discussing early Egyptian society, he refers to the scratch plow as the "trigger of civilization":

At about the same time as these first attempts at irrigation, the digging stick changed its shape; it became a simple scratch plough, with a forward-curving wooden blade for cutting the soil, and a backward-curving pair of handles with which the farmer could direct the oxen.... This simple implement may arguably be called the most fundamental invention in the history of man, and the innovation that brought civilization into being, because it was the instrument of surplus.... It is not until [a community] can produce food which is surplus to requirements, and is therefore capable of supporting those who are not food producers, that it will flourish. This development was made possible by the plough, and it caused a radical transformation of Egyptian society.

With these tools the Egyptians administered an empire whose power and influence was unparalleled in the ancient world.... The first man-made harvest freed mankind from total and passive dependence on the vagaries of nature, and at the same time tied him forever to the very tools that set him free. The modern world in which we live is the product of that original achievement, because just as the plough served to trigger change in the community in which it appeared, each change that followed led to further change in a continuing sequence of connected events. (pp. 9, 10, 12)

This example is basically technocentric — "the digging stick changed its shape," "the innovation that brought civilization into being," "the modern world is the product of that achievement" - which is no surprise considering that it comes from a book (and television series) whose thesis is that connections among innovations - their genealogy - account for significant aspects of historical development. Even so, this and similar examples in the book reveal, in spite of its thesis, that the changes described are not simple effects of technology. The beginning of a surplus economy depended upon the social conditions for change being appropriate, not just on the scratch plow. Just as the Aztecs used the wheel for toys and not for commerce, the Egyptians could have used the scratch plow in ways that did not trigger great social changes. Moreover, the second- and third-order changes developed from a complex interplay of institutional, political, cultural, social, and technological forces.

Malone and Rockart (1991) discuss analogous changes in society in terms of the higher order effects of new transportation technologies:

> A first-order effect of transportation technology was simply the substitution of new transportation technologies for the old. People began to ride in trains and automobiles rather than on horses and in horse-drawn carriages.
>
> As transportation technology continued to improve ... A second-order effect emerged: people began to travel more. They commuted further to work each day....
>
> Then, as people used more and more transportation, a third-order effect eventually occurred: the emergence of new "transportation-intensive" social and economic structures. These structures, such as suburbs and shopping malls, would not have been possible without the wide availability of cheap and convenient transportation. (p. 128)

They suggest that a similar sequence of effects may occur with new information and communication technologies. In the beginning, people will simply substitute new technologies, such as electronic mail, for the old, such as postal mail. Later, they will communicate more, as communication becomes cheaper and more convenient. Finally, organizational structures will become more communication intensive, in their estimation, more flexible and less hierarchical.

The pattern for cascaded change is similar to that for consonant change, except that here the modification of existing practices (step c in Figure 1-4) leads to more fundamental social change, such as new organizations or changed social roles. When this happens, the early period of implementation in a particular setting results in a new social context that, in turn, influences later realizations of the innovation. In the changed context, the original innovation takes on a new meaning, becoming effectively a new innovation. Thus we get a cycle of changes, the {a-b-c-d-e(-a)} path in Figure 1-4.

One limitation of the cascaded change model as presented is that it assumes inadvertent

change. The innovation is introduced, it gets used, and later we observe social change. This may be appropriate when we consider many types of innovation (for example, dams, hybrid seeds, or snowmobiles), for in those cases, the innovation is not designed primarily to bring about social change, even though it typically does so. In contrast, the primary purpose of some innovations is precisely to change social relations. This is especially true of educational innovations like ENFI.

Redesign of the innovation. Innovations influence social practices when they are seen as consonant with existing values, whereas dissonance in the match of an innovation to the social context can lead to nonuse or to unforeseen changes. These are the principal forms of change described in many studies of social change. In each case the innovation is a given, often one imposed by a colonizer, a government agency, or a large corporation. What is studied is the adaptation of the culture to the innovation, or the assignment of meaning to the innovation within the culture.

But innovations themselves are never fixed; they are active elements in the organization of relationships among people. As such, they are continually interpreted and evaluated with respect to the way they express these relationships. Whenever the expression is not appropriate as, for example, when the relationships change, there is a tension that must be resolved. Sometimes s tension results in further discordant social change. At other times, and varying degrees, people can and do change the innovation.

Generally what happens is this: People try out an innovation, find that me aspects of it are worthwhile, some are not, and others need to be changed. When they have the power to modify the innovation they do so. This process of interpretation evaluation, selection, and modification is effectively a re-creation of the innovation by the users. Whether users do in fact re-create an innovation depends in part on their technical skills and their ability to select or modify elements of the innovation, but more importantly on their having the social power to do so. There is of course great variation n the degree to which users are allowed to shape the technology they use Bjerknes, Ehn, & Kyng, 1987; Hawkins, 1987a; Papanek, 1973; Suchman, 1988).

The user redesign process follows the path {a-b-c-d-g-i} in Figure 1-4. Notice that the dissonance in step g is between the new practices and the social values of the users. One especially interesting case of user re-creation is that of open-ended innovations in education, such as ENFI. On the one hand, many such innovations call for the active participation of users (teachers and students) in the ongoing development of the innovation. Thus the definition of the innovation is explicitly dynamic: Developers intend that users will re-create the innovation. A key assumption behind this intention is that the social values of the users and the developers will be similar. Ironically, what often happens is that these open-ended innovations are in fact used because they are flexible enough to be re-created in the image of the traditional classroom they were intended to supplant (Cohen, 1988; Cuban, 1986).[3]

Finally, we cannot omit the role played by the developers in the development process. They look at the use of their innovation in different contexts, and choose to modify it to respond to perceived problems with its use. Upon seeing that the innovation is realized in unforeseen ways, they may learn things that guide a revision of the innovation. Thus development becomes a cycle in which innovations are repeatedly evaluated and re-created.[4]

The model for developer redesign includes dissonance between the new practices and the idealized practices envisioned by the designers - between their goals and the realities of use. The innovation is thus realized in unex-

pected, and often undesired, ways. Many times the story ends there; but the innovation can usually be changed. In response to the dissonance, developers may re-create the innovation so that desired effects are better achieved. This process is represented by the cycles (a-b-c-j-f)

and @a-k-l-f) in Figure 1-4.

Implications for the study of innovations

The variety of paths that the realization process of a given innovation may follow show that the effects of an innovation on a social system are not properties of the innovation or of the social system alone. Moreover, the very boundaries and character of the innovation must be seen as a process shaped by users and developers. The most significant indications of an innovation's characteristics are revealed only through a careful study of the properties that emerge as it comes to be used in different settings.

When television became available, for example, many people predicted the demise of radio. Yet radio has survived and prospered as a communications medium, even in situations in which television programming and receivers are widely available. There are several reasons for this. Radio does not require the user to focus attention on the communications device itself as television does. A radio listener is free to drive a car, work, or read a book and still benefit from a radio program. The apparent limitations of radio can also be advantages. Many people find that the video portion of the television signal distracts them when they listen to music, or constrains their imagination in a dramatic presentation. Moreover, the mere possibility of video has been transformed into a necessity - television demands good video, to the point that programming, even news, is structured to highlight interesting visual material, excluding that which cannot be made visual (Mander, 1978). Thus radio offers a balance of content different from that of television. Finally, although television technology has become simpler and less expensive, it is still much easier to set up a radio station than a television station. It is also easier for the consumer to install a radio than a television. Most homes may have one or two televisions, but radios are ubiquitous. They are found in cars, small boats, shower stalls, and swimming pools; they are attached to clocks, telephones, headbands, and exercise machines. This general availability and easy use of radios has thus allowed the older medium to survive in the face of apparently superior technology.

A forecast for the radio and television industries in 1950 might have focused primarily on technical characteristics, perhaps comparing the two media in terms of information transfer rate or on the ability to represent different categories of information. Such a forecast might have included reports of experimental studies of people's reactions to the relative power of the different communication channels. Alternatively, a commentator might have dismissed the features of the two technologies and focused entirely on existing social needs and practices. Neither of these approaches would have provided an it(icqliate accounting for the ways in which these technologies came to be u,,cd, how they changed, and how differences in their actual use emerged.

It is difficult to assess relative technical strengths and weaknesses of different technologies; therefore, it is difficult to forecast their growth. The radio/FV example illustrates an additional problem: The modes of use as well as the technology itself change over time. Thus, although the prevalence of radio has actually increased, the uses of radio have changed dramatically since the introduction of television. People no longer gather around the radio for an evening's entertainment as they once did. Radio drama has almost disappeared, existing primarily in some children's programs or in novelty revivals. These changes can be understood only by a careful analysis of the social contexts of use.

What happened with radio over the last four decades was a rich interaction of social contexts with the technology. The technology was adapted to fit new social needs; in turn, it catalyzed changes in social relationships. This complex and iterative interaction between the innovation and the social context — each modifying the other in a dynamic system of

interrelationships — is one reason it is so difficult to analyze the "effect" of an innovation.

Rather than thinking of interactions between a fixed innovation and a static social context, we should view the process of innovation as a *transaction* (Dewey & Bentley, 1949; Rosenblatt, 1978) among ideas, cultural values, sentiments, institutional structures, social practices, and the structure of the innovation. An appreciation of the nature of this process leads to new perspectives on innovation and social change, new questions to ask about the effects of innovations, and a new approach to evaluation.

The shift in perspective from the view that realizations are distortions of an ideal to one in which realizations

are creations that result from active problem solving has implications for the evaluation of educational innovations. In a method of evaluation known as *situated evaluation* (defined more fully in Chapter 2), the social context in which the educational innovation is used becomes central. In this method, questions such as the following must be considered:

- How do the overall goals, practices, and gateposts in the institution shape, constrain, or direct the use of the innovation?
- How do teachers' pedagogical theories, personalities, and practices relate to the way they incorporate the innovation into their classrooms, the kinds of activities they engage in, and their evaluations of its success?
- How do student characteristics and expectations affect the implementation of the innovation and their evaluations of its success?
- How do features of the technology - hardware, software, room location and layout — affect the innovation's use?
- How do available resources - funding, technical assistance, teacher time — affect the innovation's use?

These elements of the educational setting — the institution, the teacher, the students, the technology, and the resources - contribute to the different realizations of the innovation and the degree to which it will be successful. In order to understand the implementation process and to evaluate the outcomes of the introduction of the innovation, we need to identify and characterize realizations of the innovation. In the chapters to follow we discuss the diverse paths taken in the realizations of network-based classrooms.

Notes

[1] Staudenmaier (1985) provides an in-depth discussion of these issues in a history of the first twenty years of the journal Technology and Culture. There is a gradual move from innovation-focused discourse toward more "contextual" discourse that considers the settings in which technologies are used.

[2] It is important to notice that this dissonance is between the practices and the ideas of the users of the technology, not between their practices and the ideas of the technology's developers. The latter case is discussed in the section titled "Redesign of the innovation."

[3] The resistance-to-change model described earlier could be considered a special case of users re-creating the innovation. In that case users anticipate that use of the innovation will be dissonant with their values; accordingly, they refuse to use it or adopt it in a token fashion. Thus the resistance response, which might be termed an "unfaithful use" in traditional evaluation discourse, is in our terms a re-creation of the innovation by the users.

[4] This distinction between changes initiated by users of the innovation, as they mold the innovation to fit their needs and abilities, and those initiated by its developers need not be absolute. In fact, many of the problems that arise with the introduction of innovations can be attributed to separation of and conflict between users and developers (Akrich, 1987; Noble, 1984; Papanek, 1973; Staudenmaier, 1985; Suchman, 1988). Successful innovations require collaborative development. Our abstraction here of separate processes reflects the realities of most innovation development today.